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Policy, Research, and External Affairs

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Children and Intra-household Inequality

A Theoretical Analysis

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Structural models of intra-household allocation of resources must be modified to make intra-household allocation nonlinear in total household resources.

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This paper — a product of the Research Advisory Staff, Office of the Vice President, Development Economics — is part of a larger effort in PRE to understand the design of poverty alleviation policies. Copies are available free from the World Bank, 1818 H Street NW, Washington, DC 20433 Please contact Jane Sweeney, room S3-026, extension 31021 (19 pages, with figures).

Arguing that resources within the household are not allocated according to need, several researchers have tried to mo l intra-household allocative behavior. Haddad and Kanbur (1990) argued that as households become better off, intra-household inequality first increases and then decreases. The behavior of intra-household inequality as household welfare improves is clearly important for policy, as interventions are often restricted to the household level — although the objective is to improve the welfare of the least-well-off individual.

Kanbur shows here that many of the tractable derivations of intra-household resource allocation are available in what might be called the "linear expenditure systems" framework.

He analyzes the relationship between intra-household inequality and total household resources for models of intra-household allocation that lead to a linear expenditure reduced form.

He then investigates three structural models:

- Household welfare maximization
- Cooperative bargaining
- A noncooperative game with children as public goods

He indicates how these models should be modified to produce reduced forms that are better represented in the evidence.

Contents

1. Ir .oduction

The issue of intra-household inequality has received increasing attention over the past decade. A number of authors (e.g. Sen, 1984) have argued that resources within the household are not distributed according to need, and this has led to attempts by others to model intra-household allocative behavior (see, for example, the discussion in the recent survey by Behrman and Deolalikar, 1989). The question of what happens to intra-household inequality when total household resources increase has been raised by Haddad and Kanbur (1990c). They argue, on the basis of empirical evidence on calorie adequacy from the Philippines, that as households become better off, intra-household inequality first increases and then decreases - in other words, there appears to be an intra-household Kuznets curve. The behavior of intra-household inequality as the household becomes better off is clearly important for policy, since interventions are often restricted to the household level while the objective is to improve the welfare of the least well off individuals. It is also important as a reduced form test of alternative models of intra-household allocation.

It turns out that many of the tractable derivations of the reduced form relationship between intra-household inequality and total household resources, and indeed many of the other tractable implications of intra-household allocation, are only available in what might be described broadly as the "linear expenditure systems" framework. The objective of this paper is to lay out a generic analysis in this framework, and to show how a number of formulations of intra-household allocation essentially lead to special cases of the framework. This includes (i) household welfare maximization, (ii) intra-household allocation viewed as the outcome of a Nash co-operative bargain and (iii) intra-household allocation as a Nash non-cooperative game, with children as public goods. Each of these structural models has been suggested as an explanation for intra-household allocation. We start, however, by setting out the framework of linear expenditure systems.

2. Linear Expenditure Systems and the Behavior of Intra-household Inequality

We will conduct the discussion in terms of a variable x that depicts total household resources. The index $i = 1, 2, \ldots, n$ will identify each of the n individuals in a household, so that x_i is the flow of resources to the ith individual, and $\sum_{i=1}^{n} x_i = x$. At this level of generality x can have several interpretations. The most convenient way is perhaps to think of it as some measure of welfare. More concretely, it can be thought of as calorie intake relative to requirement (as in Haddad and Kanbur, 1990a,c). Our focus is on how the allocation x_i ($i = 1, 2, \ldots, n$) changes with x. In reduced form, we can write

$$(1) \qquad x_i = x_i(x) \quad ; \quad i = 1, 2, \ldots, n$$

as the functional relationship derived from the structural model of intra-household allocation. A measure of inequality of the intra-household allocation can then be written as

(2) $$I = I(x_1\ x),\ x_2(x),\ \ldots,\ x_n(x))$$

Given the reduced form (1), we can therefore derive the relationship between intra-household inequality and total household resources.

Consider the following special case of (1):

(3) $$x_i = \bar{x}_i + \alpha_i(x - \sum_{j=1}^{n} \bar{x}_j);\ i = 1,\ 2,\ \ldots,\ n$$

$$\alpha_i > 0 \quad \forall_i$$

$$\sum_{i=1}^{n} \alpha_i = 1$$

In the next two sections we will discuss structural models that lead to th. reduced form. For now, notice that (3) is nothing but a linear expenditure system for the n "commodities" i = 1, 2, ..., n, with intercepts $\bar{x}_i$, total expenditure x, super-numerary expenditure $x - \sum_{j=1}^{n} \bar{x}_j$, and marginal propensity to spend on commodity i given by x_i. How does intra-household inequality behave as total household resources change in this framework?

Before answering this question let us rewrite

$$(4) \qquad x_i = (\bar{x}_i - \alpha_i \sum_{j=1}^{n} \bar{x}_j) + \alpha_i x$$

$$= (\bar{x}_i - \alpha_i \bar{x}) + \alpha_i x$$

$$= \beta_i + \alpha_i x$$

where $\bar{x} = \sum_{j=1}^{n} \bar{x}_j$

$$\beta_i = \bar{x}_i - \alpha_i \bar{x}$$

$$\sum_{i=1}^{n} \beta_i = 0$$

The share of x_i in x, s_i is given by

$$(5) \qquad s_i = \frac{x_i}{x} = \alpha_i + \beta_i x^{-1}$$

Thus the squared coefficient of variation of x_i, which is the same as the variance of s_i, is given by

$$(6) \qquad \sigma_s^2 = \sigma_\alpha^2 + 2\sigma_{\alpha\beta}\, x^{-1} + \sigma_\beta^2 x^{-2}$$

where σ_s^2, σ_α^2 and σ_β^2 are the variances of the subscripted variables, and $\sigma_{\alpha\beta}$ is the covariance of α and β.

We will focus on σ_s^2 as our measure of intra-household inequality. We are interested in its behavior as a function of x. It is easily shown that this function has a unique minimum at

$$x^* = \frac{-\sigma_\beta^2}{\sigma_{\alpha\beta}}$$

Of course, the economically relevant range for x is $x \geq \bar{x} > 0$. Thus if $\sigma_{\alpha\beta} \geq 0$ then $\frac{d\sigma_s^2}{dx} < 0$ for all x in the relevant range, as shown in figure 1. If $\sigma_{\alpha\beta} <$ 0 then there are two cases to consider. If $\bar{x} \geq x^* > 0$ i.e. if $\sigma_{\alpha\beta} \leq \frac{-\sigma_\beta^2}{\bar{x}}$, then $\frac{d\sigma_s^2}{dx} > 0$ for $x > \bar{x}$, as shown in figure 2. But if $x^* > \bar{x}$ i.e. if $0 > \sigma_{\alpha\beta} > \frac{-\sigma_\beta^2}{\bar{x}}$, then σ_s^2 follows a U-shape in the relevant range of $x > \bar{x}$, as shown in figure 3.

Translating these conditions on α_i and β_i into conditions of α_i and x_i, after making the normalization assumption that $\bar{x} = 1$, we get the following, complete, characterization:

(7a) $\qquad \sigma_{\bar{x}\alpha} \geq \sigma_\alpha^2 \Rightarrow \frac{d\sigma_s^2}{dx} < 0 \quad \forall\, x > \bar{x}$

(7b) $\qquad \sigma_{\bar{x}}^2 \leq \sigma_{\bar{x}\alpha} < \sigma_\alpha^2 \Rightarrow \frac{d\sigma_s^2}{dx} > 0 \quad \forall\, x > \bar{x}$

(7c) $\qquad \sigma_{\bar{x}\alpha} < Min\,(\sigma_\alpha^2, \sigma_{\bar{x}}^2) \Rightarrow \frac{d\sigma_s^2}{dx}$ has a U shape in the range $x > \bar{x}$

Figures 4a and 4b characterize the different ranges of $\sigma_{\bar{x}\alpha}$ for the cases where $\sigma_{\bar{x}}^2 < \sigma_\alpha^2$ and where $\sigma_{\bar{x}}^2 > \sigma_\alpha^2$.

The behavior of intra-household inequality in a linear expenditure system framework depends, therefore, on the pattern of covariance between the parameters $\bar{x}_i$ and α_i of the system. But we already have an important result in (7). Notice that in no circumstances can the linear expenditure system generate the inverse U shape of the Kuznets curve, for which there is some evidence in the data (Haddad and Kanbur, 1990c). This would seem to be a strong argument against models of intra-household allocation that lead to a linear expenditure system as a reduced form. The next two sections consider some applications of this general characterization.

3. Two simple applications

3.1 Household Welfare Maximization

Suppose that the intra-household allocation (1) is the result of the maximization of a household welfare function:

$$(8) \qquad \max_{x_1, x_2, \ldots, x_n} W(x_1, x_2, \ldots, x_n)$$

$$\text{s.t.} \sum_{i=1}^{n} x_i = x$$

If the welfare function were specialized to the following case of the Stone-Geary utility function,

$$(9) \qquad W(x_1, x_2, \ldots, x_n) = \sum_{i=1}^{n} \alpha_i \ln (x_i - \bar{x}_i) \; ; \; \alpha_i > 0 \quad \forall i$$

$$\sum_{i=1}^{n} \alpha_i = 1$$

then it is well known that the optimal solution to (8) is exactly as given by (3).

Hence the behavior of intra-household inequality is determined by the pattern of the minimum consumption levels $\bar{x}_i$ and the weights α_i given to the individuals in the welfare function. If, for example, $\bar{x}_i$ and α_i are negatively correlated then case (7c) obtains and intra-household inequality follows a U shape, not the inverse-U shape of the Kuznets curve that is found empirically by Haddad and Kanbur (1990c). If, on the other hand, all α_i are the same, then case (7a) obtains and inequality decreases continously. If $\sigma_{\bar{x}\alpha}$ is positive, case (7c) may still obtain, provided the covariance between $\bar{x}$ and α is not too high. If $\sigma_{\bar{x}\alpha}$ is high enough, in particular if it is higher than σ_α^2, then intra-household inequality will decrease as the household's resources increase.

3.2 Two Person Nash Co-operative Bargaining

Haddad and Kanbur (1990b) have investigated the behavior of intra-household inequality for a two person household where allocations are determined as outcomes to a Nash bargain. As is well known, if we specify the total resources being bargained over as x, the threat points of the two individuals as $\bar{x}_1$, and $\bar{x}_2$, and their "bargaining strength" parameters as α_1, and α_2 ($\alpha_1 + \alpha_2 = 1$), then the Nash solution to the co-operative bargain is given as the solution to the following problem:

$$\max_{x_1,\, x_2} \; (x_1 - \bar{x}_1)^{\alpha_1} \; (x_2 - \bar{x}_2)^{\alpha_2} \tag{10}$$

$$\text{s.t. } x_1 + x_2 = x$$

But a logarithmic transform of the maximand in (10) gives us (9) for n = 2 and hence (3) as the solution with n = 2.

We are back, therefore, to the results in (7) for the case of n = 2, which we have already discussed in section 3.1. The two person Nash bargaining model with fixed $\bar{x}_1$, $\bar{x}_2$, α_1 and α_2 leads to one of the three patterns for intra-household inequality, shown in (7a), (7b) and (7c), as total household resources increase. In the symmetric bargaining model, with $\alpha_1 = \alpha_2$, we have $\sigma_{\bar{x}\alpha} = \sigma_\alpha^2 = 0$ and therefore case (7a) -- inequality decreases continuously. Since none of these outcomes is like the Kuznets curve observed in the data (Haddad and Kanbur, 1990c), this model will have to be modified. Haddad and Kanbur (1990b) consider endogenizing $\bar{x}_1$ and $\bar{x}_2$ as x changes and find that, under certain conditions, intra-household inequality does indeed follow a Kuznets curve.

4. A Further Application: Children as Public Goods

The two person Nash bargaining framework is clearly inappropriate when there are children involved, unless we assume that the welfare of children is subsumed under the objective function of one of the two players. When children are present, one way of modelling their role in the household is as public goods, from which adults get utility but towards the maintenance of which each adult makes a voluntary contribution. This perspective, which is reflected, for example, in the policy debate on whether welfare payments intended for children should be given through the father or the mother, leads to a model of non-cooperative Nash equilibrium between the players, in a game over contributions for child up-keep. What are the implications of this model for intra-household inequality?

Consider the case where there are two adults, indexed 1 and 2, and a child, indexed 3. The consumptions of the three individuals are x_1, x_2, and x_3. The two adults have individual resources y_1 and y_2, which they decide to split between own consumptions, x_i, and contributions to the child's consumption, c_i. Clearly, $c_1 + c_2 = x_3$. The child's consumption is a public good, i.e. x_3 enters both adults' utility functions (along with their own respective consumptions). Each adult decides on his or her contribution to child consumption conditional upon the other adults' contribution.

Let adult i's utility function be given by

$$(11) \qquad u_i = \gamma_i \ln (x_i - \bar{m}_i) + (1 - \gamma_i)\ln(c_1 + c_2 - \bar{x}_3) \qquad i = 1,2$$

This is a Stone-Geary from with minimum consumptions for the adult and $\bar{m}_3$ for the child. The weights on the contribution of own consumption and child consumption (after logarithmic transformation) are γ_i and $(1 - \gamma_i)$. For simplicity, we assume that neither adult's own consumption affects the other's utility. The two adults solve the problems:

$$(12) \qquad \underset{x_i,\, c_i}{Max} \quad \gamma_i \ln(x_i - \bar{m}_i) + (1 - \gamma_i)\ln(c_i + c_j - \bar{m}_3)$$

$$\text{s.t.} \quad x_i + c_i = y_i$$

$$i = 1,2 \quad ; \quad j = \begin{cases} 1 \text{ if } i = 2 \\ 2 \text{ if } i = 1 \end{cases}$$

This leads to the following solutions for $i = 1, 2$

$$(13a) \qquad x_1 = \bar{m}_1 + \gamma_1 \, [y_1 - (\bar{m}_1 + \bar{m}_3 - c_2)]$$

$$(13b) \qquad c_1 = [\bar{m}_3 - c_2] + (1 - \gamma_1)[y_1 - (\bar{m}_1 + \bar{m}_3 - c_2)]$$

$$(14a) \qquad x_2 = \bar{m}_2 + \gamma_2 \, [y_2 - (\bar{m}_2 + \bar{m}_3 - c_1)]$$

$$(14b) \qquad c_2 = [\bar{m}_3 - c_1] + (1 - \gamma_2)[y_2 - (\bar{m}_2 + \bar{m}_3 - c_1)]$$

A number of authors have considered the utility function (11) for public goods games (e.g. Ulph, 1988 and Woolley, 1988) and have derived the Nash equilibrium solution to c_1 and c_2. Solving for c_1 and c_2 simultaneously in (13b) and (14b), we get the following as interior solutions to the Nash game:

(15) $$c_1 = \frac{(1-\gamma_1)y_1 - \gamma_1(1-\gamma_2)y_2 + \gamma_1(1-\gamma_2)\bar{x}_3 - (1-\gamma_1)\bar{x}_1 + \gamma_1(1-\gamma_2)\bar{x}_2}{1-\gamma_1\gamma_2}$$

(16) $$c_2 = \frac{(1-\gamma_2)y_2 - \gamma_2(1-\gamma_1)y_1 + \gamma_2(1-\gamma_1)\bar{x}_3 - (1-\gamma_2)\bar{x}_2 + \gamma_2(1-\gamma_1)\bar{x}_1}{1-\gamma_1\gamma_2}$$

Using these in (13a) and (14a), and noting that $x_3 = c_1 + c_2$, we have a complete characterization of consumption allocation in the interior Nash equilibrium:

(17) $$x_1 = \frac{\gamma_1(1-\gamma_2)(y_1+y_2) + (1-\gamma_1)\bar{m}_1 - \gamma_1(1-\gamma_2)\bar{m}_2 - \gamma_1(1-\gamma_2)\bar{m}_3}{1-\gamma_1\gamma_2}$$

$$x_2 = \frac{\gamma_2(1-\gamma_1)(y_1+y_2) + (1-\gamma_2)\bar{m}_2 - \gamma_2(1-\gamma_1)\bar{m}_1 - \gamma_2(1-\gamma_1)\bar{m}_3}{1-\gamma_1\gamma_2}$$

$$x_3 = \frac{(1-\gamma_1)(1-\gamma_2)(y_1+y_2) + [\gamma_1(1-\gamma_2) + \gamma_2(1-\gamma_1)]\bar{m}_3 - (1-\gamma_1)(1-\gamma_2)(\bar{m}_1+\bar{m}_2)}{1-\gamma_1\gamma_2}$$

It will be seen that the equations in (17) are in fact in the form of a linear expenditure system. If we define the following:

(18) $$x = y_1 + y_2$$

$$\alpha_1 = \frac{\gamma_1(1-\gamma_2)}{1-\gamma_1\gamma_2} \;;\; \alpha_2 = \frac{\gamma_2(1-\gamma_1)}{1-\gamma_1\gamma_2} \;;\; \alpha_3 = \frac{(1-\gamma_1)(1-\gamma_2)}{1-\gamma_1\gamma_2}$$

$$\bar{x}_1 = \bar{m}_1 \;;\; \bar{x}_2 = \bar{m}_2 \;;\; \bar{x}_3 = \bar{m}_3$$

then it is seen that (17) is nothing other than (3) for $i = 1, 2, 3$. Thus the reduced form of the children as a public goods model of intra-household allocation, where preferences of adults as between own consumption and child's consumption are given by Stone-Geary utility functions, leads once again to the linear expenditure system.

Equations (17) and (18) can be used to discuss intra-household inequality in this model. Notice first of all that the allocation depends only on $x = y_1 + y_2$, i.e. on total household resources. The division of income does not matter. This is a strong result which has immediate policy implications. It suggests that, in this framework, the policy debate on targeting of child payments to the mother or the father is irrelevant - the public goods game serves as a perfect aggregator and what matters is the total level of resources.

As discussed by Bergstrom and Varian (1985), the above is a general result for public goods, and does not depend on the Stone-Geary utility function. However, what the linear expenditure specialization allows us to do is to consider explicitly the behavior of inequality as a function of total household resources. We know from the discussion in section 3 that only one of three outcomes is possible - inequality always increasing, inequality always decreasing, or a U shape where inequality first decreases and then increases. To the extent that the empirical evidence points to an inverse - U shape where inequality first increases and then decreases, this is an argument against the children as a public goods model - at least against the interior Nash equilibrium solution of this model.

Consider now possible corner solutions. Following Woolley (1988) consider the case where one adult, say adult 2, is constrained to set $c_2 = 0$. Using this in (13) and (14) we get the following allocation as solution:

(19a) $$x_1 = \bar{m}_1 + \gamma_1[y_1 - (\bar{m}_1 + \bar{m}_3)]$$

(19b) $$x_2 = y_2$$

(19c) $$x_3 = \bar{m}_3 + (1 - \gamma_1)[y_1 - (\bar{m}_1 + \bar{m}_3)]$$

It is seen immediately that the distribution of total household resources between the adults now <u>does</u> affect the intra-household allocation. Most particularly, increases in y_1 increase x_1 and x_3, but increases in y_2 only increase x_2. If we think of individual 2 as being the male adult, this model does provide a rationalization of targeting extra resources to the female, since at least some of these will get to the child.

The allocation in (19) allows a richer variety of shapes in the relationship between intra-household inequality and total household resources. but it depends on how exactly the increase in resources is divided between y_1 and y_2. If increments are distributed in constant proportion, so that $y_1 = \delta x$ and $y_2 = (1 - \delta)x$, then we get the allocation

(20) $$x_1 = (1 - \gamma_1)\bar{m}_1 - \gamma_1\bar{m}_3 + \gamma_1\delta x$$

$$x_2 = (1 - \delta)x$$

$$x_3 = \gamma_1\bar{m}_3 - (1 - \gamma_1)\bar{m}_1 + \delta(1 - \gamma_1)x$$

This is, of course, another linear expenditure system, so that a similar characterization to the one in (7) obtains. The only chance for a variation is if after a certain level of x the interior solution comes into play. This switch in regimes between two different linear expenditure systems can lead to a richer pattern of behavior.

If the increment in x comes solely from y_2 (say, male income) then the behavior depends on the position of x_2 relative to x_1 and x_3. If x_2 is already greater than x_1 and x_3, the inequality will increase inexorably. Consider now the case where x increases through increases in y_1 (female income). Unit increments in this are divided according as γ_1 to x_1 and $(1 - \gamma_1)$ to x_3. In this case both x_1 and x_3 will increase relative to x_2. Thus inequality will decrease. It should then be clear that if initial increments to household resources go to the male, and subsequent increments to the female, then we will indeed get the Kuznets relationship of inequality first increasing and then decreasing as total household resources increase.

5. Conclusion: The Need for Non-Linear Extensions

We have seen that models of intra-household allocation that lead to linear expenditure system allocations imply very specific relationships between intra-household inequality and total household resources. We have derived these relationships and have argued that they can be used as reduced form tests of particular models. Of course, this procedure has well known problems, but it is hoped that this way of proceeding will give guidance on how the structural models should be modified. The essential message is that they have to be modified so as to make intra-household allocation non-linear in total household resources:

(i) In the household welfare maximization models it means using utility functions that are more general than the Stone-Geary form. It should be noted, however, that most generalizations of demand systems in the income dimension essentially involve introducing the logarithm of income as an independent variable. This monotonic transformation will not of course affect our conclusions on the shape of the relationship between intra-household inequality and total household resources. In any event, most attention in generalized demand systems is given to the cross-price effects (e.g. the Almost Ideal Demand System of Deaton and Muellbauer, 1980) across commodities, an issue which is not relevant to the models developed here.

(ii) In the Nash co-operative bargaining models, the modifications must involve endogenizing the threat points as total household resources increase. This is done by Haddad and Kanbur (1990b) and they do find that with this modification a Kuznets curve is possible.

(iii) In the children as public goods model, departures from the Stone-Geary utility function are likely to make the solution intractable. An alternative is to examine corner solutions of the Nash game, as a way not only of possibly generating the Kuznets curve, but also of rationalizing policy concerns about the need to target incremental resources to female adults. All three of these avenues hold out interesting possibilities for further research.

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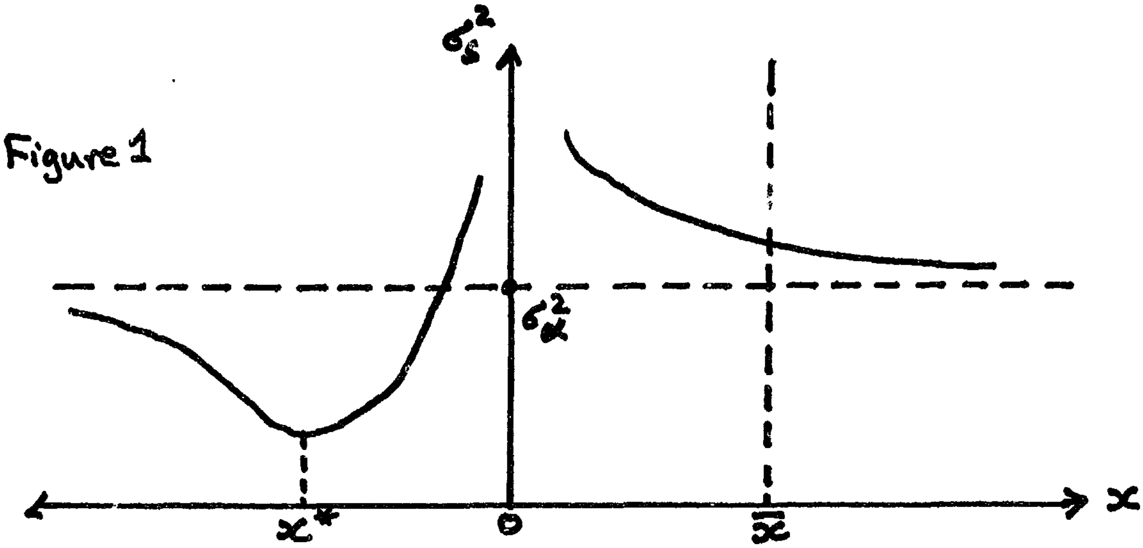


Figure 1

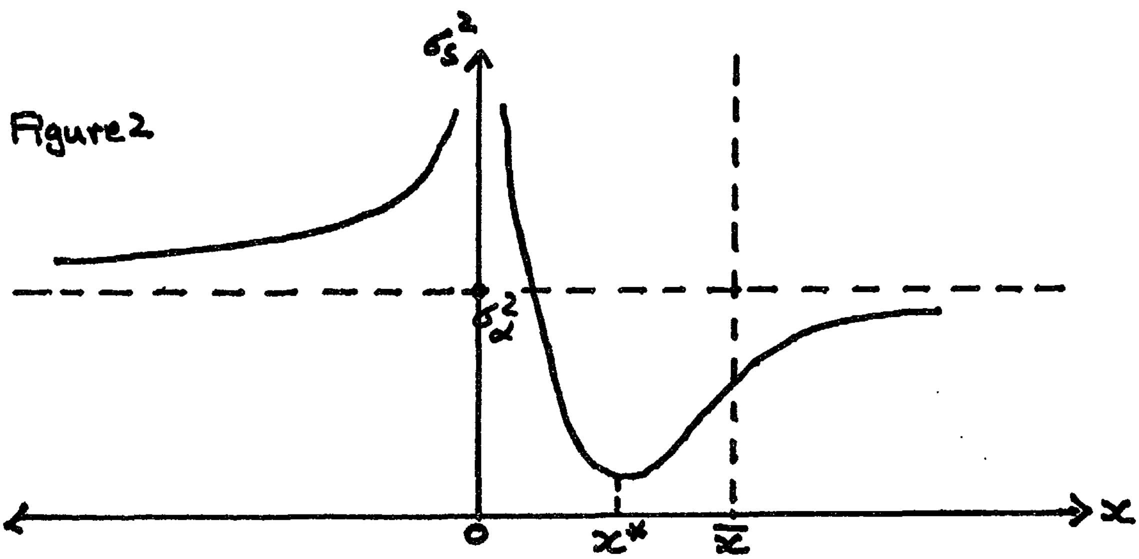


Figure 2

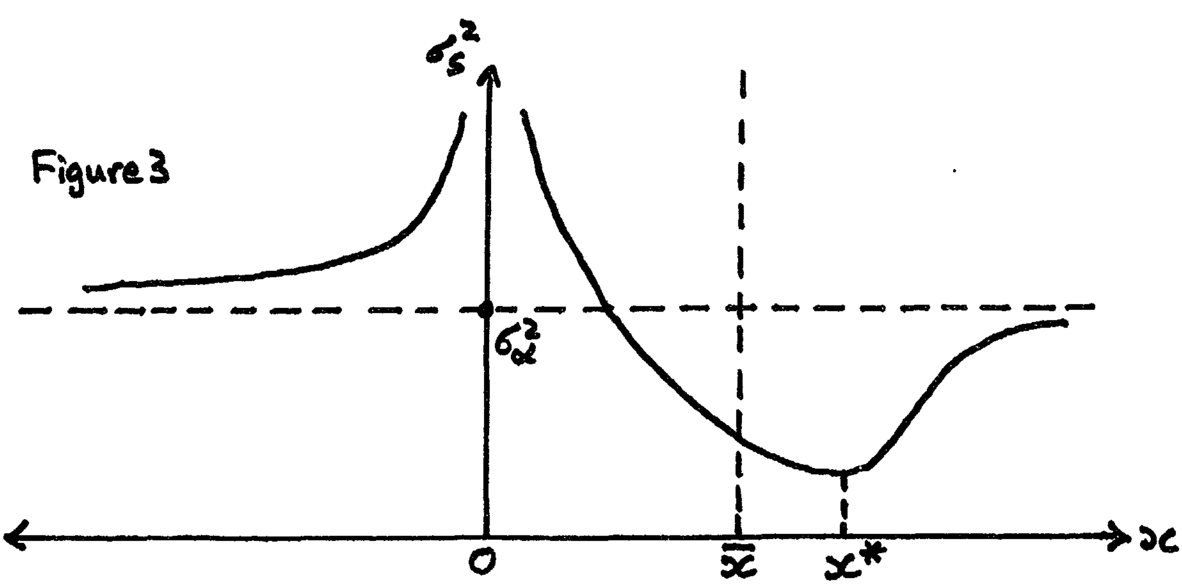
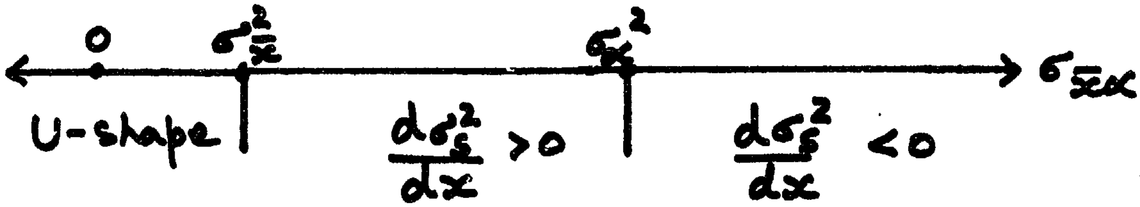
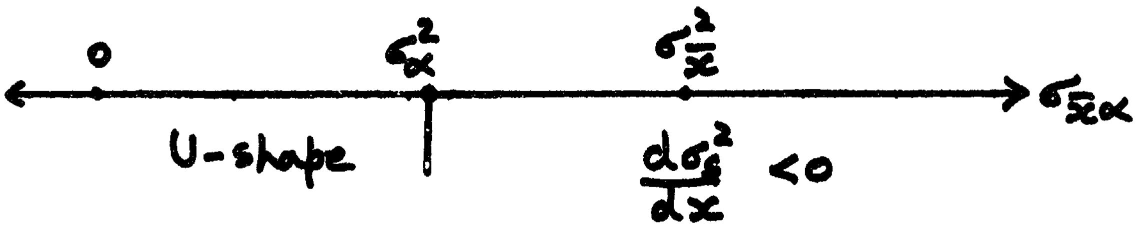


Figure 3



<u>Figure 4a</u>



<u>Figure 4b</u>

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